

## NEUROPLASTICITY

Those of us educated in the mid-twentieth century were taught that by the age of three the human brain had done all the physical changing and growing it was ever going to do. Today we know that view is totally incorrect.

The last quarter century of research in neurobiology has taught us that the brain is *massively plastic*. What this means is that the brain continually reorganizes itself in response to stimulation of various kinds. (Although the popular term “rewired” is somewhat misleading, the overall idea is right—the brain changes and organizes itself differently based on the inputs it receives.) According to John Skoyles of University College, London “The biggest discovery in the past 25 years is how plastic brain functioning is.”

Additionally, the old idea that we have a fixed number of brain cells that die off one by one has been replaced by research showing that our supply of brain cells is continually replenished. This process of never-ending reorganization and replenishing of is technically known as neuroplasticity.

How do we know this is true? Here are quick summaries of just a few of the animal and human studies of the past several years showing brain development happening well beyond the first few year of life:

- Ferrets’ brains were physically rewired, with inputs from the eyes switched to where the hearing nerves went and vice versa. Their brains changed to accommodate the new inputs.
- A well-known researcher found that rats in “enriched” environments showed brain changes compared with those in “impoverished” environments after as little as two weeks.
- Imaging experiments showed that when blind people learn Braille, “visual” areas of their brains lit up. Similarly, deaf people use their auditory cortex to read signs.
- Scans of brains of people who tapped their fingers in a complicated sequence that they had practiced for weeks showed a larger area of motor cortex becoming activated then when they performed sequences they hadn’t practiced.

### Chapter 5

## Do They Really Think Differently?

**“The biggest discovery in the past 25 years is how plastic brain functioning is.”**

—*John Skoyles, University College, London*

In the previous chapter, I discussed how the differences between Digital Native students and their Digital Immigrant parents and teachers lie at the root of a great many of today’s educational problems. I suggested that “Digital Natives” brains may well be physically different as a result of the digital input they received growing up. And I suggested that learning via digital games is one good way to reach Digital Natives in their “native language.”

Lest you think this is all the rantings of one lone person (me), I’m about to give you some detailed evidence that supports my claims, evidence that comes from neurobiology, social psychology, and studies done on children using games for learning.

Let me be clear that there is still a huge amount we don’t yet know about how the brain works. But certain things we have learned relatively recently do help our understanding. The most important of these is neuroplasticity.

- Japanese subjects were able learn to “reprogram” their circuitry for distinguishing “ra” from “la,” a skill they “forget” soon after birth because their language doesn’t require it.
- Researchers discovered that an additional language learned later in life goes into a different place in the brain than the language or languages learned as children.
- Intensive reading instruction experiments with students aged 10 and up appear to create lasting chemical changes in key areas of the subjects’ brains.
- An MRI comparison of musicians’ and non-players’ brains showed a five percent greater volume in the musicians’ cerebellums, ascribed to adaptations in the brain’s structure resulting from intensive musical training and practice.

We are only at the very beginning of understanding and applying brain plasticity research. The most exciting part so far is that the research shows that the brain maintains its plasticity for life.

## MALLEABILITY

Research by social psychologists shows that people who grow up in different cultures don’t just think about different things, they actually *think differently*. The environment and culture in which people are raised affects and even determines many of their thought processes. The reason is what we just saw—brains that undergo different developmental experiences develop differently.

While no one has yet directly observed Digital Natives’ brains to see whether they are physically different from Digital Immigrants’, the indirect evidence for this is extremely strong. It appears highly likely that this ability for brains to reorganize has profoundly affected the way today’s young people behave and think.

## PRACTICE REQUIRED

It’s critical to keep in mind that brains and thinking patterns don’t just

change easily or quickly—it takes a lot of work. As one researcher puts it, “Brain reorganization takes place only when the animal pays attention to the sensory input and to the task.” One brain-research-based remedial reading program requires students to spend 100 minutes a day, 5 days a week, for 5 to 10 weeks to create desired changes, because, says another researcher, “it takes sharply focused attention to rewire a brain.”

Hmmm. Several hours a day, five days a week, sharply focused attention—does that remind you of anything? Oh, yes—video games! Ever since *Pong* arrived in 1974, kids have been gradually reprogramming their brains to handle the speed, interactivity, and other factors in the games. “Children raised with the computer develop hypertext minds,” says one observer. “They leap around. It’s as though their cognitive structures were parallel, not sequential.” Children’s brains have been so successfully reworked, this observer continues, “that the kind of linear thought process that dominates our educational systems can actually slow down learning in people whose brains developed through game and Web-surfing processes on the computer.”

Many have surmised that Digital Natives use different parts of their brain and think in different ways than adults when at the computer, and now it seems likely that their brains are almost certainly physiologically different, much in the same way musicians’ brains are. (We should emphasize that these physical changes are still mostly conjecture, and, if they exist, are relatively small compared with the entire human brain. They are, however, important.)

Thinking skills that research shows enhanced by repeated exposure to computer games and other digital media include:

- “Representational competence,” that is, reading visual images as representations of three-dimensional space.
- “Multidimensional visual-spatial skills,” i.e. the ability to create “mental maps” and do “mental paper folding” (picturing the results of various origami-like folds in your mind without actually doing them).
- “Inductive discovery”—acting like a scientist by making observations, formulating hypotheses, and figuring out the rules governing the behavior of a dynamic representation.

- “Attentional deployment”—i.e. the ability to focus on several things at the same time, and being able to respond faster to unexpected stimuli.

And while individually these individual cognitive skills may not be new, the emerging combination and intensity is, and that's part of what makes Digital Natives so different from their predecessors.

### WHAT ABOUT ATTENTION SPANS?

We hear parents and teachers complain so often about the Digital Natives' attention spans that the phrase “the attention span of a gnat” has become a cliché. But is it really true?

Notice that kids' attention spans are *not* short for everything. They're not short for games, for example, or for music, or for anything else that actually interests the Digital Natives. As a result of their formative experiences with digital objects, though, Digital Natives do crave *interactivity*—they expect an immediate response to their each and every action. Traditional schooling, as we've discussed, provides very little of this.

So it isn't that Digital Natives *can't* pay attention; it's often that *they choose not to*. Remember what the t-shirt from Chapter 1 said? “I'm just not listening.”

And, interestingly enough, they don't *have to* succeed, at least not all the time. Research done for *Sesame Street*, for example, reveals that young children actually watch television not continuously, but “in bursts,” tuning in just enough to get the gist and be sure it makes sense. In one key experiment, half the children were shown the same program as the other half while in a room filled with toys. As expected, the kids with toys were distracted and watched the show only about 47 percent of the time, as opposed to 87 percent in the group without toys. But when the children were tested for how much of the show they remembered and understood, the scores were exactly the same. “We were led to the conclusion that the 5-year-olds in the toys group were attending quite strategically, distributing their attention between toy play and viewing so that they looked at what was for them the most informative part of the program,” said the lead researcher on the study. “The strategy was so effective that the children could gain no more from increased attention.”

### WHAT HAVE WE LOST?

One big question is whether anything has been lost in the Digital Natives' “reprogramming” process. One area that appears at first to have been affected is reflection. Reflection is what enables us, according to many theorists, to generalize, as we create mental models from our experience. It is, in many ways, the process of learning from experience. In our twitch-speed world, there seems to many to be less and less time and opportunity for reflection, and this development concerns many people.

Certainly one of the most interesting challenges and opportunities in parenting and teaching Digital Natives is to find ways to include reflection and critical thinking in their learning, either built into the instruction or through a process of instructor-led questioning and “debriefing.”

Still, in observing Digital Natives, I have come to see that reflection, like so much else in the Digital Natives' world, is also something that can happen—and is happening—faster. Whenever a player loses in a computer game and he or she has to start over, their mind typically races over the moves that got them to that point, asking themselves “What did I do wrong?” and “What am I going to do differently this time?”

This is reflection at its most effective, although it is rarely if ever verbalized or even made completely conscious.

### BUT DOES LEARNING FROM COMPUTER AND VIDEO GAMES ACTUALLY WORK?

It does. There is a great deal of evidence that games that are well designed do produce learning, and lots of it.

One large set of studies was conducted by The Lightspan Partnership, now a part of Plato Learning. In the 1990s they created a series of video (PlayStation) games for curricular reinforcement. Their reasoning was this: Elementary school, when you strip out the recesses and the lunch and the in-between times, actually consists of about three hours of instruction time spread out over a typical 9:00 to 3:00 school day. So assuming, for example, that learning games were only 50 percent educational, if you could get kids to play them for six hours over a weekend, you'd effectively add a day a week to their schooling! Six hours is far less than a Digital

Native would typically spend over a weekend watching TV and playing other videogames. The trick, though, is to make the learning games compelling enough to actually be used in place of the other games kids played. So Lightspan spent a fortune (over \$100 million) making "real" games, which included "real," curricular content—not just random drills with graphics like many other "edutainment" products.

To test their games' effectiveness, Lightspan conducted studies in over 400 individual school districts (all of which they made available on a CD). The studies show definitively that the kids learned from the games. Lightspan found that the game-playing kids increased their vocabulary and language skills by almost 25 percent over the non-game-playing control groups, and by over 50 percent in math problem solving.

Another set of studies comes from a company called Click Health, which made action-adventure games to help kids develop the skills to self-manage asthma and diabetes. They conducted rigorous clinical trials, funded by National Institutes of Health. What they found was that kids with diabetes who played their diabetes game at home (compared to a similar group of diabetic kids who played an entertainment game) showed measurable gains in their diabetes-related knowledge, their belief that they could take charge of their condition (self-efficacy), their communication about the disease with peers and parents, and their diabetes self-care behaviors. Most importantly, players' diabetes-related urgent care visits to the doctor and emergency room visits declined from an annualized 2.5 per year down to 0.5 visits per year, while the other group did not change at all. That's a drop of 77 percent in required urgent care due to the game!

Perhaps the largest, broadest-based studies are currently being conducted by the U.S. military, which has a quarter of a million 18-year-olds to educate every year. Their results, while still preliminary, are extremely positive. The military knows that games are exactly what it takes to reach these Digital Natives. "If we don't do things their way, they're not going to want to be in our environment," said the head of the Pentagon's Office of Readiness.

Not only does the military create its own games, but it uses games that can be bought in any store as part of its training. The military calls this "off-loading"—using off-the-shelf games to teach basics before they put people on expensive simulators.

Most importantly, the military has become convinced by watching game-based learning working operationally in the field. "We've seen the success of our mission simulators time and time again," says a Pentagon official. The practical-minded Department of Defense trainers are perplexed by those educators who say "We don't know yet that games work—we need to do more studies." "We know it works," they retort. "We just want to get on with using it."

But while the educators (and parents) sit back and debate, the Digital Natives are not standing still. They are busy constructing and settling into cyberspace, creating a digital life all their own. For a glimpse into the often hidden, online world of the Digital Native, turn the page.